PORTABLE TWO-WHEELED SELF-BALANCING PERSONAL TRANSPORT VEHICLE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a continuation of Ser. No. 15/092,460 filed Apr. 6, 2016, which claims the benefit of U.S. provisional application No. 62/222,779, filed Sep. 24, 2015, for a "Self-Balancing Scooter" by Daniel Bryan Laird Edney. This U.S. provisional application is hereby incorporated by reference in its entirety.

BACKGROUND

[0002] The invention pertains to two-wheeled, self-balancing electric-powered personal transport vehicles.

[0003] Technology for self-balancing vehicles has been well-known to mechanical engineers for many years. For example, more than fifty years ago, U.S. Pat. No. 3,399,742 ("the '742 Patent") entitled "Powered Unicycle" issued to an inventor named Malick, and discloses a self-balancing one-wheeled vehicle using a "vertical sensing gyroscope" to relieve the rider of the need to constantly "maintain a vertical balance." When the rider of the unicycle shifts his or her weight forward, the vertical sensing gyroscope senses the shift in weight and causes the wheel to increase rotational speed to compensate for the forward lean. When the rider shifts her weight backward, the vertical sensing gyroscope again senses the shift in weight rearward and causes the rotational speed of the wheel to slow to compensate for the backward shift. Thus, the speed of the vehicle is controlled by the rider "shifting his weight fore and aft" ('742 Patent, col. 8, lines 56-68).

[0004] U.S. Pat. No. 5,701,965 to Kamen et al., entitled "Human Transporter," teaches a two-wheeled balancing scooter or balancing wheelchair which balances the rider by active control of the wheel to regulate the tilt of the complete vehicle and rider combination in the manner of an inverted pendulum. The rider sits or stands on the vehicle holding a handle, the tilt of the device is measured using angle or level sensors such as gyroscopes, and a control system applies appropriate motor torque to keep the device upright. The rider therefore controls the vehicle's forward and reverse motion by leaning.

[0005] Other examples of two-wheeled self-balancing vehicles are disclosed in U.S. Pat. No. 5,791,425 entitled "Control Loop for Transportation Vehicles" issued in 1998 to Dean Kamen et al. ("the '425 Patent"). The '425 patent discloses several types of two-wheeled self-balancing vehicles, including a two-wheeled self-balancing vehicle where the rider stands on a platform mounted between the two wheels, grips a set of handlebars that are mounted on a post connected to the platform, and steers with the use of a joystick mounted on the grip of the handle. (See '425 Patent, FIG. **21** and col. 9, line 33). The '425 patent also discusses an alternative form of the two-wheeled vehicle that avoids the handlebars and joystick combination by equipping the standing platform on the vehicle with force transducers to detect the rider's leaning. The provided force transducers "sense leftward and rightward leaning" and related controls turn the vehicle left and right "as a result of the sensed leaning." ('425 Patent, col. 9, lines 20-23).

[0006] The '425 patent also describes the use of a "pitch sensor" to sense the vehicle's pitch and provide it to the electrical motor control loop so that if the rider leans forward or backward, the vehicle drives forward or backward in response to maintain vertical balance. ('425 patent, col. 9, lines 14-20).

[0007] More recently, two-wheeled, electric-powered self-balancing vehicles for a standing rider, also commonly known as "hoverboards", have become a well-known, popular form of personal transport vehicle. Conventional hoverboards are self-balancing electric vehicles comprising two platform halves connected by a center pivot, with a wheel mounted on each platform end. Each half generally has at least two sensors, generally a gyroscope and an accelerometer, for detecting angle from gravity and rate of change respectively. Control circuitry and associated software or firmware uses the data from the sensors to independently control the electric motor connected to each wheel and self-balance each platform on either side. Thus, if the user tilts the left foot platform forward, forward torque is applied to the left wheel to drive the left foot platform towards self-balancing. If the user tilts the right foot platform rearward, reverse torque is applied to the right wheel to drive the right foot platform toward self-balancing. If the user tilts the left foot platform forward and the right foot platform rearward, forward and reverse torque is applied to the left and right wheels respectively so that the hoverboard rotates in a generally clockwise direction.

[0008] One example of this hoverboard type of two-wheeled electric self-balancing vehicle has been described in U.S. Pat. No. 8,738,278 ("the '278 Patent"), entitled "Two-Wheel Self-Balancing Vehicle with Independently Movable Foot Placement Sections", issued on May 27, 2014 to Shan Chen. The '278 patent discloses a two-wheeled self-balancing vehicle that allows the user to ride standing on his or her two feet, with each foot on an independently movable foot placement section (or platform). The rider may thus independently control each wheel by moving each foot placement section independently of the other. Each side of the vehicle has its own position sensor (which may be a "gyroscopic sensor") to sense the pitch (referred to the '278 patent as "tilt" or sometimes just "position") of the platform. The sensors provide independent measurement of the position of the respective platform boards, and the sensed position information is used to drive the corresponding motors and wheels connected to each platform ('278 patent, col. 3, lines 4-11). In such a scooter having independently tilting foot positions, steering is achieved by the user tilting the left and right sections at different angles to cause differential motion of the left and right wheels. Separate motors provide independent control over the driving of the wheel associated with each foot placement section.

[0009] The '278 patent also discloses an alternative form of the two-wheel self-balancing vehicle where a single frame or housing may be used to enclose the two independently moveable foot placement sections, but the single frame or housing remains "sufficiently flexible" that the two halves of the board are "effectively" two sections that "move independently" with respect to each other for "independent control" of the wheels. (See '278 patent, col. 4, lines 27-33).

[0010] Two-wheeled self-balancing electric vehicles have thus been known in the art for many years. Balancing two-wheeled scooters known in the art use either handle